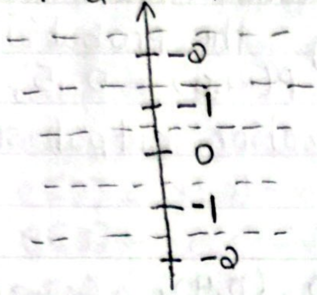
Homework 8 Deep Shah
CPE 462
5/8/25

I pledge my honor that I have abided by the Stevens Honor System. Deep A. Shah

8.1 Quantization and Huffman Coding



8.1.1 Use a 5-level uniform scalar quantizer as shown to quantize the sample sequence {0.25, -1.10, -0.15, 2.35, -1.40, 0.10, 0.90, -0.05}. Provide the output sequence.

Quantized output: {0, -1, 0, 2, -1, 0, 1, 0}
without seperators: 0 -1 0 2 -1 0 1 0

8.1.2 Design the best fixed-length code for the outputs of this quantizer, i.e. for an alphabet A = {2.0, 1.0, 0.0, -1.0, -2.0}. Then encode the quantization output sequence from 8.1.1 using the code.

Since there are more than 4 outputs, more than 2 bits are needed. 5 outputs can be contained within 3 bits.

A fixed length code for alphabet A (need at least 3 bits for each codeword):

2.0	000
1.0	001
0.0	010
-1.0	011
-2.0	100

The coded output from 8.1.1 is {010, 011, 010, 000, 011, 010, 001, 010} (24 bits)

Without seperators: 010 011 010 000 011 010 001 010

8.1.3 Design a Huffman code for the same alphabet $A = \{2.0, 1.0, 0.0, -1.0, -2.0\}$ assuming the probabilities $P(2.0) = 0.15$, $P(1.0) = 0.20$, $P(0.0) = 0.40$, $P(-1.0) = 0.15$, $P(-2.0) = 0.10$. Then encode the quantization output sequence from 8.1.1 using this code.

Symbol (probability)			
0.0 (0.40)	0.0 (0.40)	0.0 (0.40)	s3 (0.60) 0
1.0 (0.20)	s1 (0.25)	s2 (0.35) 0	0.0 (0.40) 1
2.0 (0.15)	1.0 (0.20) 0	s1 (0.25) 1	
-1.0 (0.15) 0	2.0 (0.15) 1		
-2.0 (0.10) 1			

S4: Probability is 1.0

Resulting Huffman code:

0.0	1
1.0	000
2.0	001
-1.0	010
-2.0	011

The coded output from 8.1.1 is $\{1, 010, 1, 001, 010, 1, 000, 1\}$ (16 bits)

Without separators:
1 010 1 001 010 1 000 1

8.2 Differential Coding (Assuming there is no quantization or coding error, i.e. $\hat{x} = x[n]$)

8.2.1 Use differential coding with the predictor $\tilde{x}[n] = \hat{x}[n-1]$ to encode the sequence: 10 11 12 11 12 13 12 11

$x[0] = 10$
$e[1] = x[1] - x[0] = 11 - 10 = 1$
$e[2] = x[2] - x[1] = 12 - 11 = 1$
$e[3] = x[3] - x[2] = 11 - 12 = -1$
$e[4] = x[4] - x[3] = 12 - 11 = 1$
$e[5] = x[5] - x[4] = 13 - 12 = 1$
$e[6] = x[6] - x[5] = 12 - 13 = -1$
$e[7] = x[7] - x[6] = 11 - 12 = -1$

8.2.2: Use the same predictor to encode another sequence.

10 −10 8 −7 8 −8 7 −7

$x[0]=10$

$e[1] = x[1]-x[0] = -10-10 = -20$

$e[2] = x[2]-x[1] = 8+(+10)=18$

$e[3] = x[3]-x[2] = -7-8=-15$

$e[4] = x[4]-x[3] = 8+(+7)=15$

$e[5] = x[5]-x[4] = -8-8=-16$

$e[6] = x[6]-x[5] = 7+(+8)=15$

$e[7] = x[7]-x[6] = -7-7=-14$

This sequence is even more difficult to code than the original sequence.

8.2.3 Find a better linear predictor for this second sequence in 8.2.2 and perform the differential coding again. (Hint: your objective is to make sure the coded sequence has generally low amplitudes.)

10 −10 8 −7 8 −8 7 −7

$\tilde{x}[n] = -\hat{x}[n-1]$

$x[0]=10$

$e[1] = x[1]-x[0] = +(+10)-(10)=0$

$e[2] = x[2]-x[1] = -10+(+8) = -2$

$e[3] = x[3]-x[2] = (-7)+(+8)=1$

$e[4] = x[4]-x[3] = (-7)+(+8)=1$

$e[5] = x[5]-x[4] = (-8)+(+8)=0$

$e[6] = x[6]-x[5] = 7-(+(+8))=-1$

$e[7] = x[7]-x[6] = -7+(+7)=0$

8.3. Q

Run-length coding will produce (via zig-zag):

{(0,1), (0,1), EOB}

0.1Q

{(0,13), (0,6), (0,−4), (0,2), (0,5), (1,−1), (0,−1), (0,3), (0,1), (0,1), (0,1), (0,−2), (0,−1), (2,1), (1,1), (0,−1), (2,1), EOB}

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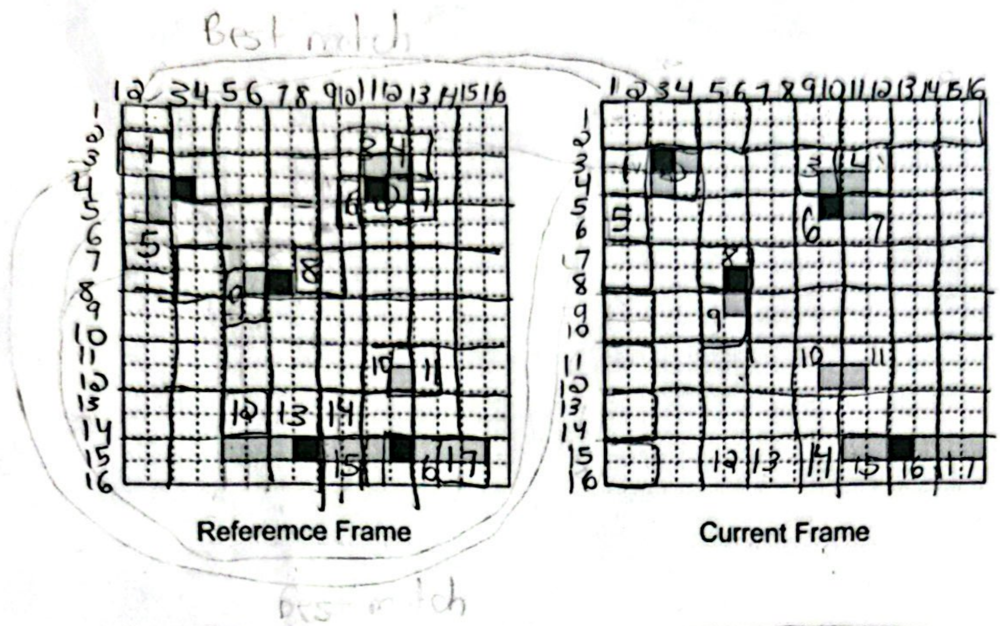

(0,0)	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)
(0,1)	(-8,-1)	(0,0)	(0,0)	(-1,1)	(-1,1)	(0,0)	(0,0)
(0,-1)	(0,0)	(0,0)	(0,0)	(-1,1)	(-1,1)	(0,0)	(0,0)
(0,0)	(0,0)	(0,0)	(-1,0)	(0,0)	(0,0)	(0,0)	(0,0)
(0,0)	(0,0)	(0,1)	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)
(0,0)	(0,0)	(0,0)	(0,0)	(-2,0)	(-1,0)	(0,0)	(0,0)
(0,0)	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)	(0,0)
(0,0)	(0,0)	(0,2)	(0,2)	(0,2)	(1,0)	(1,0)	(1,0)

Motion Vector

1: (2,4) − (2,3) = (0,1)
2: (3,3) − (11,4) = (-8,-1)
3. (10,4) − (11,3) = (-1,1)
4. (11,4) − (12,3) = (-1,1)
5. (2,6) − (2,7) = (0,-1)
6. (10,5) − (11,4) = (-1,1)
7. (11,5) − (12,4) = (-1,1)
8. (6,8) − (7,8) = (-1,0)
9. (6,9) − (6,8) = (0,1)
10. (10,12) − (12,12) = (-2,0)
11. (11,12) − (12,12) = (-1,0)
12. (5,16) − (5,14) = (0,2)
13. (7,16) − (7,14) = (0,2)
14. (9,16) − (9,14) = (0,2)
15. (11,15) − (10,15) = (1,0)
16. (13,15) − (12,15) = (1,0)
17. (15,15) − (14,15) = (1,0)

Everywhere else has no change, so it is (0,0)

1 → Gray box   0 → White box
2 → Black box

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1																
2			2	1												
3																
4										1	1					
5										2	1					
6																
7																
8						1										
9						1										
10																
11																
12										1	1					
13																
14																
15											1	1	2	1	1	1
16																

Prediction Frame

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1																
2																
3																
4			1													
5																
6																
7																
8						1										
9																
10																
11																
12																
13																
14																
15																
16																

Residual Frame

(Difference Frame)
Difference between the current frame and prediction frame

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